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None

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INT CL[4] G01S , G02B

(54) Abstract Title
Detecting apparatus

(57) For determining the angle of incident radiation a plurality of detecting heads (10),(Fig.1), each having a plurality of focussing elements (12) are coupled via fibre optics (13) to a remote evaluation station (15) having radiation detectors (18). There is one detector (18) for each focussing element (12) per head (10). The detectors (18) deliver output signals to peak hold circuits (21) and these signals are converted to serial form by a multiplexer (22) and digitised by an analogue-to-digital converter (23) to be processed by a microprocessor (24). The microprocessor (24) also receives a signal from threshold level detectors (19) which are connected to respective heads (10) so as to inform the microprocessor which head (10) is subject to incident radiation. A first coarse measure of incidence angle is provided by microprocessor (24) according to the amplitude of the digitised signals and their order in the digitised series whilst a second refined measure of incidence angle is provided by the microprocessor (24) according to the amplitude ratios of the digitised signals by comparison of these amplitude ratios with a correlated set of known interpolation angles and known ratios.

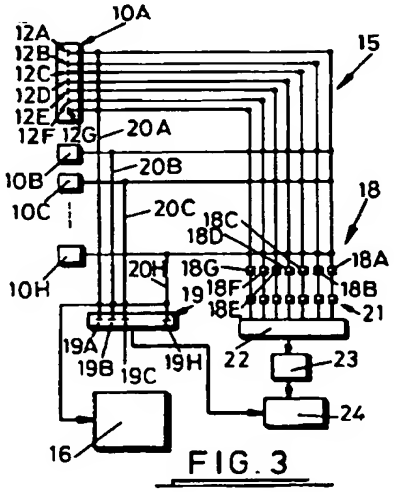

FIG. 3

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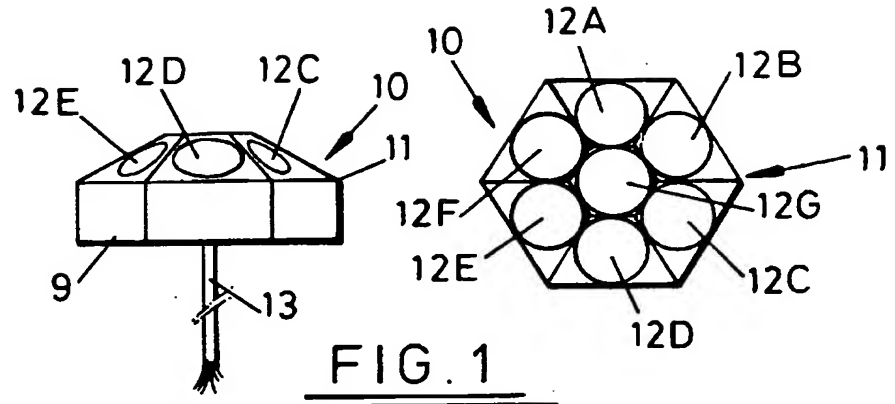

FIG. 1

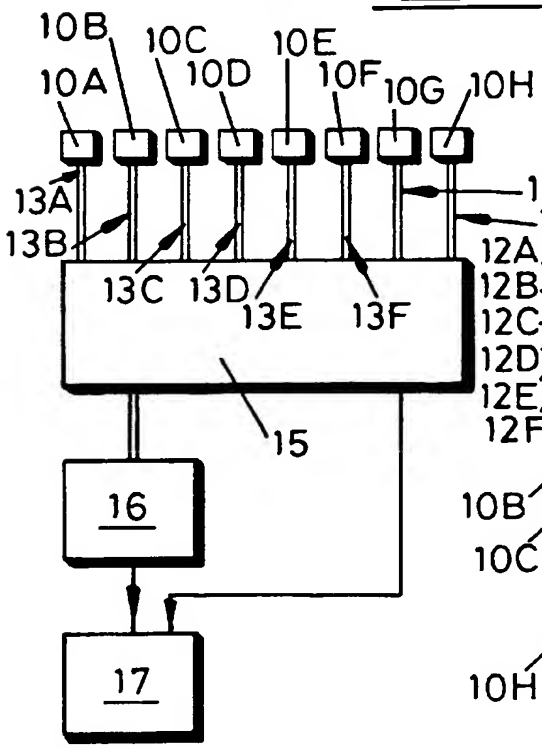

FIG. 2

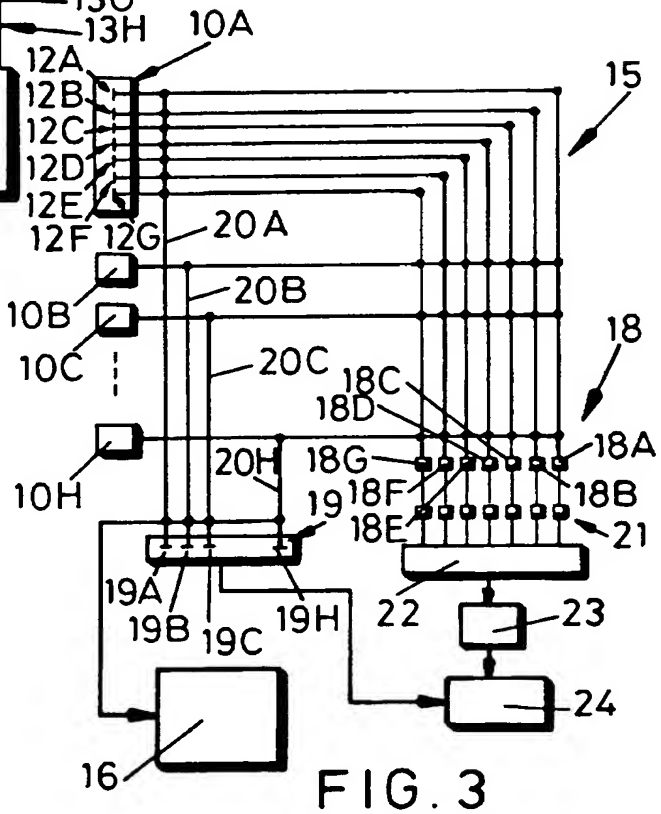

FIG. 3

DETECTING APPARATUS

This invention relates to apparatus for recognising and detecting the direction of optical radiation, particularly laser radiation, incident on an irradiated object.

According to the present invention apparatus for recognising and detecting the direction of incident optical radiation comprises at least one radiation collecting head provided with a plurality of radiation focussing elements having respective field of view directions, fibre light guide means coupled to said focussing elements for receiving collected radiation from the respective elements and delivering at least part of the collected radiation to a remote evaluation station, said evaluation station comprising electro-optic detection means, temporary storage means coupled to the detector means for storing the output signals therefrom, an analogue-to-digital converter, multiplexer means interposed between the temporary storage means and the converter whereby the converter is arranged to provide digital data items in serial form ordered in relation to the respective collecting elements, means for correlating the data items of the series with the field of view directions of the respective collecting elements to provide a coarse measure of the direction of a radiation beam incident on said head according to the amplitudes of the respective data items, means for effecting amplitude processing of pairs of data items in the series to obtain

amplitude ratios, and means for establishing interpolation angles from said ratios by comparison with a plurality of known interpolation angles correlated with a plurality of known ratios and held in a data store, whereby to provide a refined measure of the direction of the incident radiation.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 illustrates a collecting head forming part of apparatus according to the present invention;

Fig. 2 illustrates schematically the apparatus referred to in Fig. 1; and

Fig. 3 shows further details of the apparatus.

In the drawings Fig. 1 illustrates a radiation collecting head 10 in plan and elevational views. The head 10 comprises a dome-like housing 11 formed with a plurality (thirteen in total) of planar facets 9 and selected facets (seven in total) carry respective radiation collecting and focussing elements 12A, 12B, 12C, etc., referred to generally by numeral 12. As illustrated there are six elements 12 arranged in a ring about a central collecting element (12G). At the focus of each element 12 the end of a fibre light guide is located and the light guides are collected into a bundle 13 which emerges from head 10 and delivers the radiation signals to a remote evaluation station 15 shown in Fig. 2. Each element 12 has a 60° field of view with the fields of view of adjacent elements 12 overlapping by about

50% so that the head 10 is provided with a field of view of about 120-150°.

A plurality of such heads 10 disposed at different orientations may be mounted on a platform for the purpose of recognising and detecting the direction of optical radiation, particularly laser radiation, which is incident on the platform. Typically the platform is provided with eight heads 10A, 10B, 10C .... 10H as is shown in Fig. 2. with the eight fibre bundles 13A, 13B, ... 13H delivering the radiation to the remote evaluation station 15. Station 15 evaluates the angular direction of the radiation incident on the heads 10 and provides an output to a grating spectrometer 16 (or similar device) for the purpose of recognising the specific nature of the radiation incident on the heads 10 by wavelength determination, and also delivers incident radiation angular information to a display 17.

One format of station 15 is illustrated in Fig. 3 and comprises a set of seven radiation detectors 18A, 18B, etc. referred to generally by numeral 18 coupled simultaneously by fibre optic bundles to each of the eight heads 10, respective detectors 18A, 18B, 18C, etc. being coupled to respective elements 12A, 12B, 12C, etc. in each head 10, although this is only shown in full for head 10A, the connections for the remaining heads 10B, ... 10H, being illustrated diagramatically. The signals from each head 10A, 10B, 10C, etc. are also monitored via respective summing

channels 20A, 20B, etc., referred to generally by numeral 20 by a set of eight threshold detectors 19A, 19B, etc. referred to generally by numeral 19 to determine which head 10 is illuminated, and the grating spectrometer 16 is coupled to the input of the threshold detectors 19. The summing channels 20 are fibre optic and coupled to collect 50% of the signal output by each of the seven elements 12 per head 10. Likewise the signals to the grating spectrometer 16 are coupled via fibre optics which collect 50% of each of the signals delivered to the seven detectors 19.

The amplitude detectors 18 provide an electro-optic conversion of the received signals and this information is delivered to a set 21 of peak-hold circuits the outputs of which are sequentially connected to an analogue-to-digital converter 23 by way of a multiplexer 22 in order that the output of the converter 23 can provide digital data items in serial form and which are ordered in relation to the respective collecting elements 12A, 12B, 12C, etc. of the heads 10.

In another form the remote evaluation station 15 comprises a set of amplitude detectors for each head 10 and each detector is connected to a peak-hold circuit and the output from the peak-hold circuits are connected to an analogue-to-digital converter via a multiplexer.

The serialised digital data items provided by the converter 23 are delivered to a microprocessor 24 which is arranged to correlate the data items of the series with the

known field of view directions of the respective collecting elements 12 of the particular head 10 receiving the incident radiation as determined by the threshold detectors 19, and by determining which data items have a non-zero value, a first coarse measure of the direction of a radiation beam incident on the heads 10 is determined. This first measure is established by the relatively small number of collecting elements 12 which are likely to be illuminated by an incident laser radiation beam. The microprocessor 24 additionally effects amplitude processing of pairs of data items in the series to obtain amplitude ratios and then establishes from these ratios interpolation angles to provide a refined measure of the direction of the incident radiation. For this purpose the microprocessor 24 incorporates a data store holding a predetermined plurality of interpolation angles correlated against a plurality of amplitude ratios against which a comparison with the measured ratios is made. It will be understood that the direction of incident radiation requires to be determined in three dimensions and that the coarse and refined measures of this direction effectively provide measures of the three direction cosines of the incident radiation direction.

For the purpose of detecting incident radiation in laser form over a wide bandwidth encompassing the visible and infra-red parts of the spectrum it may be necessary to provide a set of collecting elements 12 which are transmissive in the visible spectrum and a further set of collecting elements 12

which are transmissive in the infrared part of the spectrum, each with a fibre bundle 13 capable of transmitting the received radiation. Materials for such components are of course well known. In order to provide complete spherical monitoring with typically available fibre optic components having individual fields of view of about 60° requires approximately 60 collecting elements 12 when the individual field of view overlap is 50% and because the evaluation station 15 is located remotely from the individual heads 10 the radiation detectors 18 can be cooled to provide maximum operating efficiency without space constraint and the resulting heads 10 can be maximally compact.

By virtue of the two-stage measurement process resolution of the direction of an incident radiation beam is very high and is of the order of a few degrees. In this connection it will be appreciated that the mutual field of view directions of the collecting elements 12 are pre-determined at the manufacturing stage of each head 10 whilst a datum field of view direction for each head 10 is determined by the location of the head 10 on the supporting platform and the collection of interpolation angles in correlation with the amplitude ratios is dependent upon the configuration of the elements 12 on each head 10.

CLAIMS

1. Apparatus for recognising and detecting the direction of incident optical radiation comprises at least one radiation collecting head provided with a plurality of radiation focussing elements having respective field of view directions, fibre light guide means coupled to said focussing elements for receiving collected radiation from the respective elements and delivering at least part of the collected radiation to a remote evaluation station, said evaluation station comprising electro-optic detection means, temporary storage means coupled to the detector means for storing the output signals therefrom, an analogue-to-digital converter, multiplexer means interposed between the temporary storage means and the converter whereby the converter is arranged to provide digital data items in serial form ordered in relation to the respective collecting elements, means for correlating the data items of the series with the field of view directions of the respective collecting elements to provide a coarse measure of the direction of a radiation beam incident on said head according to the amplitudes of the respective data items, means for effecting amplitude processing of pairs of data items in the series to obtain amplitude ratios, and means for establishing interpolation angles from said ratios by comparison with a plurality of known interpolation angles correlated with a plurality of known ratios and held in a data store, whereby to provide a refined measure of the direction of the incident radiation.

2. Apparatus as claimed in claim 1, comprising a plurality of collecting heads disposed at different orientations and wherein said evaluation station comprises threshold signal level detecting means coupled to receive at least part of the radiation collected by the focussing elements of each collecting head so as to determine which head or heads is subjected to incident radiation.

3. Apparatus as claimed in claim 1 or claim 2, including a means of determining the wavelength of radiation incident on said at least one head, said means being coupled to receive at least part of the radiation collected by the focussing elements of said at least one head.

4. Apparatus as claimed in claim 1, wherein at least some radiation focussing elements are transmissive in the visible spectrum and at least some other radiation focussing elements are transmissive in the infrared waveband.

5. Apparatus as claimed in any preceding claim, wherein the fields of view of adjacent focussing elements overlap by about 50%.

6. Apparatus for recognising and detecting the direction of incident optical radiation substantially as hereinbefore described with reference to the accompanying drawings.

PATENTS ACT 1977

EXAMINER'S REPORT TO THE COMPTROLLER
UNDER SECTION 17(5)
(The Search Report)

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Application number GB 8809523.0

FIELD OF SEARCH: The search has been conducted through the relevant published UK patent specifications and applications, and applications published under the European Patent Convention and the Patent Co-operation Treaty (and such other documents as may be mentioned below) in the following subject-matter areas:-

UK Classification H4D, G2J

(Collections other than UK, EP & PCT:) Selected US speicfications on IPC sub classes G01S, G02B

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may include only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

Category	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

CATEGORY OF CITED DOCUMENTS

X relevant if taken alone
Y relevant if combined with another cited document
P document published on or after the declared priority date but before the filing date of the present application
E patent document published on or after, but with priority date earlier than, the filing date of the present application

Search examiner
R A H CASLING

Date of search
25 May 1988

SF :